



REPORT ON ASEPTIC AND SEPTIC SURGICAL CASES, WITH SPECIAL REFERENCE TO THE DISINFECTION OF SKIN, SPONGES, AND TOWELS.¹

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I.—DISINFECTION OF THE SKIN OF THE PATIENT.

THE following is a continuation of the work upon the disinfection of the skin. In the last report, which was published in the **BRITISH MEDICAL JOURNAL** on May 28th, 1892, the difficulties of the subject were mentioned, and the following instance of them was given. Before removing a chronic mammary tumour from the breast of a young woman, the usual attempt was made to disinfect her skin. After a hot bath it was scrubbed with soap and water until, as the sister said, she almost cried. Next the skin was rubbed with carbolic lotion 1 in 20, and, finally, it was enveloped in an antiseptic dressing for eighteen hours before operation, and at the operation it was rubbed and washed again with perchloride of mercury lotion 1 in 1,000. It will be allowed that strenuous efforts had been made to disinfect this skin, but, nevertheless, I grew from it the bacillus epidermidis, a streptococcus with as many as fifteen elements in a chain, staphylococcus albus, and many diplococci. These cultures were obtained by simply removing a piece of the skin at the operation, and dropping it into the usual sterilised broth, which was afterwards kept for some days at summer temperature in an incubator.

Here it is necessary to meet an obvious objection to the method of investigation which I have pursued. To introduce the skin or materials into the broth, they were cut off with sterilised scissors, and dropped into it wet with perchloride of mercury or carbolic lotion. It might reasonably be said that this lotion was sufficient to account for the absence of growth in some of the experiments. However, this is, I think, negatived by the result of the following simple experiment: Six ordinary broth cultures received from a fine pipette 2, 4, 8, 16, 24, and 32 drops of perchloride of mercury lotion, 1 in 1,000, and were afterwards inoculated with a cultivation of micrococci grown from one of the bits of skin. On the following day, after having been kept at summer temperature for twenty-four hours, each contained an obvious

¹Two previous reports on this subject have appeared in the **BRITISH MEDICAL JOURNAL** (October 25th, 1890, and May 28th, 1892).

growth, and this afterwards increased until all the broth was turbid. Now I should estimate that never more than two or three drops of lotion were introduced in any of the other experiments with skin or materials.

In passing, it may be remarked that the above is rather a striking instance of the inefficacy of the chemicals which we are accustomed to use. The cocci grew luxuriantly in a mixture of broth and perchloride of mercury, the strength of which I should estimate to have been 1 in 5,000.

A similar experiment done with carbolic acid gave similar results. Six broth tubes were mixed with 10, 20, 30, 40, 50, and 60 drops of carbolic lotion, strength 1 in 20, and then inoculated with the same culture of skin bacteria. In seventy hours the first four were turbid, and contained abundant growth, and before the end of the week the others followed suit, the one with 50 drops becoming turbid before the one with 60.

Thus I think we may safely infer that in none of the experiments was sufficient of the chemical introduced with the skin or other material to mar the result.

At the beginning of this year other experiments similar to the first were done with the same result. A piece of the skin of a girl's neck, from which I was about to remove a cervical exostosis, was prepared in the same way as the woman's breast. The broth into which a portion of it was placed soon contained cocci, diplococci, and strings of from four or five cocci. This wound healed by first intention. Also the ordinary carbolic lotion failed to disinfect the skin of a woman's chest from which I removed a fatty tumour. *Diplococcus epidermidis albus* grew in the broth. The wound healed by first intention under a single dressing.

Again, the skin of the breast was prepared in the same manner for the removal of a large tumour, which proved to be a carcinoma. From this a rather large staphylococcus was grown. This bacterium I have often met with in cultures inoculated with skin, or scrapings from the skin. It grows in small white circular colonies upon the surface and in the depth of the agar agar, and merely lowers the melting point of gelatine so that it is fluid at summer temperature but solid at that of the room. At first these cultures had a very strong, offensive, cheesy odour, such as is perceived when uncleanly people remove flannel vestments. This wound did not heal by first intention but had slight secondary subacute suppuration.

Under some circumstances, however, ordinary watery solutions of chemicals may suffice for the disinfection of the skin. For instance, before I performed resection of the knee upon a girl of 15, Mr. W. B. Jones, the house-surgeon, prepared the skin by scrubbing it with soft soap and water and a nail brush, washing with ether, and afterwards with carbolic lotion (1 in 20), and wrapping in an ordinary carbolic dressing soaked in 1 in 40 carbolic lotion. The operation was done on July 15th, 1893, and a piece of skin dropped into broth then is still sterile and unaltered. This girl's knee had been resected before, and the piece of skin which was taken was part of the old scar, and contained no glands or hair follicles. Part of my wound, however, failed to unite by first intention, and although there was no pain or rise of temperature, a small collection of thin pus was found under the upper part of the flap when the dressing was removed on the fourteenth day.

However, this soon got well, and did not lead to the extrusion of any of the thick silver sutures which had been inserted, and the ultimate result was very satisfactory. The cause of the suppuration was not clear, but it was probably due to an ill-applied outside dressing. I had unwisely included the back splint in the dressing—always, I think, a risky proceeding. Failure also attended our efforts to disinfect the skin by other methods.

Before operating for the radical cure of a femoral hernia I have the skin prepared as is done in the gynæcological wards of the Johns Hopkins Hospital.² Overnight Mr. Armstead, the house-surgeon, washed it thoroughly for several minutes with soap and hot water, and scrubbed it well. Next it was soaked with warm saturated solution of permanganate of potash. This was removed with a saturated solution of oxalic acid. The patient said this was the most painful part of the process. The oxalic acid was washed away with sterilised water, and then washed with perchloride of mercury lotion, 1 in 500, and covered with the usual dressing soaked in 1 in 2,000 perchloride of mercury solution until the operation. At the operation a bit of skin was removed and dropped into broth. In six days it contained the usual bacteria of the skin: monococci, many diplococci, long slender bacilli, and minute oval ones. The growth of these was unaccompanied by odour.

At the operation the skin was decidedly red and inflamed, and there were large vesicles upon the abdomen. The patient complained of pain, and the wound was dressed forty-eight hours after the operation. The next dressing was done a week later, when the wound was healed. It was quite dry, without redness or swelling, and cultures inoculated from it remained sterile. As far as I can judge, the directions for cleansing the skin were thoroughly carried out. However, I am not aware that the method has ever before been subjected to such a severe test as mine.

My friend Mr. Steedman informs me that at Leeds benzine is extensively used for cleansing the skin, and seems to give excellent results. Before removing a large exostosis from the humerus of a youth, the skin was washed with soap and hot water and scrubbed; next, it was rubbed with benzine, which was washed off with carbolic lotion (1 in 20), and a dressing applied. The cultures inoculated with this skin contained diplococcus epidermidis albus. The wound healed by first intention. The next trial was made in the same way, but with a mixture of equal parts of benzine and rectified spirit and sublimate 1 in 1,000. The spirit was used to dissolve the sublimate. The skin contained staphylococcus pyogenes albus and staphylococcus citreus, but the wound healed by first intention, and cultures inoculated from it grew nothing.

The other failures which I have had shook my confidence in the ordinary methods of skin disinfection. At the same time the fault could hardly lie in the chemicals which were used, because their efficacy is acknowledged. Evidently the error lay in the manner of their application. Now anyone can, by merely applying some ordinary lotion to the skin, satisfy himself that watery solutions of chemicals, even of carbolic acid, must be inefficacious for its disinfection. Even when they are applied to skin which has been cleansed with

² Wm. H. Welch, *American Journal of the Medical Sciences*, November, 1891.

soft soap and hot water, so much grease remains that they collect in drops, and, to use a homely phrase, run away like water off a duck's back. Also, as I pointed out in the previous report, the bacteria of the skin reside, not only upon its surface, but also in its depths; concealed in hair follicles, sebaceous glands, and sweat ducts. Thus the bacteria of the skin are not only situated in rather inaccessible places, but they are also protected from ordinary lotions by the greasy substances by which they are surrounded. I therefore began to remove as much of the fat as possible with ether, and afterwards wash the skin with chemicals dissolved in alcohol. The last, however, seemed unsuitable for the dressing, which is usually applied for some hours before the operation, and, therefore, glycerine was used. This drug has the merit of not only dissolving the disinfectants quickly and well, but it also seems to have considerable power of penetrating the skin, and, as it absorbs moisture, there is no fear of its evaporation.

Our first essay in applying these new expedients excited our most sanguine expectations. At the beginning of the year I was about to remove the breast and axillary glands of a woman for carcinoma. Before the operation she had the usual bath, and the house surgeon, Mr. Murrell, to whom I am much obliged, prepared the skin in the following way: It was thoroughly scrubbed with a nail brush, soft soap, and hot water, and then with soft soap and carbolic lotion, 1 in 20. Next it was thoroughly washed with ether, and covered with carbolic gauze, which had been soaked and saturated with a solution of perchloride of mercury in glycerine, strength 1 in 2,000. This remained in contact for twenty-four hours, and caused no eczema or blistering. A bit of the skin was put in broth, and is now quite sterile and almost quite unaltered, although more than nine months have elapsed. The wound in this case was very extensive, and was brought together with some tension; it healed, however, by first intention, and cultures inoculated from it remained sterile.

The skin was also sterile in another case, which was prepared in almost the same way. Before operating for the radical cure of an inguinal hernia, with transplantation of a misplaced testis into the scrotum, the skin was shaved, scrubbed with soft soap and a nail brush, rubbed with ether, scrubbed again with soft soap, rinsed with carbolic lotion 1 in 40, and covered for twenty-four hours with carbolic gauze soaked in sublimate glycerine 1 in 2,000. This case healed by first intention under the dressing, and nothing grew in culture media which was inoculated from it.

But our next attempts to disinfect the skin with solutions of carbolic acid and with sublimate glycerine were unsuccessful. Before operating upon a youth for the radical cure of inguinal hernia the skin was prepared by shaving, washing, and scrubbing with soft soap and water, washing with carbolic lotion, and covering with sublimate glycerine 1 in 2,000 for nearly twenty-four hours before the operation. This skin grew *diplococcus epidermidis albus*, and a bacillus which grew upon the surface of the broth with a greyish-white pellicle. Perhaps this was the ordinary bacillus epidermidis. This wound was one of the few radical cures which has suppurated, and the pus contained the same bacillus and also *staphylococcus aureus*. Whence the latter came I do not know, but contradictory results have been common in this investigation and are faithfully recorded.

The skin of a boy's knee was also treated in the same way with sublimate glycerine for the final application. The ordinary *staphylococcus pyogenes albus* was grown from this skin, and there was subacute secondary suppuration in the wound. This can hardly be said to have made the boy ill, but it made it necessary to remove the thick silver wire sutures which I had inserted. It is but right to say that another cause for the suppuration might have been found in the disturbance of his limb and dressings owing to his extreme restlessness upon the night of the operation. But Mr. Murrell, who had to renew and replace the dressings, performed that duty with extreme care.

These failures were disappointing and seemed to be due to some fault in the perchloride. Being aware that Sir Joseph Lister claims great penetrative and germicidal powers for carbolic acid I determined to try that drug by itself for the attempted disinfection of the skin. Therefore Mr. W. B. Jones, the house-surgeon, who has been most assiduous in carrying out these experiments, prepared the skin by shaving and washing in soft soap and water in the usual way, scrubbing with a nail brush, washing with ether, rinsing with carbolic lotion (1 in 20), and finally by covering it with a dressing of carbolic gauze soaked in glycerine of carbolic (1 in 40).

This plan was successful in the case of a boy upon whom I operated for reposition of a misplaced testicle into the scrotum with subsequent suture of the inguinal canal. The operation was done on September 2nd, 1893, and the skin, which was then placed in broth, is still unaltered. Mr. Jones says that this skin was very easy to clean, being devoid of hairs and very smooth. The wound healed by first intention and under a single dressing.

Also the skin of the groin of a young woman was aseptic after having been prepared with carbolic lotion and carbolic glycerine. The operation was done for a congenital hernia of the ovary, and the wound healed by first intention under a single dressing. This skin was likewise white and easy to clean, although studded with many hairs.

Our success has not been the same with integument which presented greater difficulties. The rough, coarse, neglected skin of a man who was operated upon for an irreducible femoral epiplocele grew *staphylococcus pyogenes albus* and *diplococcus epidermidis albus*, but his wound healed by first intention under a single dressing.

When removing two very large diffuse lipomata from a man's neck I had an opportunity of seeing what could be done for the disinfection of the scalp. Mr. Furnivall applied the carbolic method, with the addition of a rinsing with 1 in 500 watery solution of biniodide of mercury after the ether. However, in spite of this extra precaution, the broth became infected with *staphylococcus albus*. The extensive wounds both healed by first intention under a single dressing.

I attributed this failure mainly to the inefficacy of watery solutions, and, therefore, Mr. Furnivall kindly prepared some skin in the same way as the scalp, but used a 1 in 500 solution of biniodide of mercury in rectified spirit after the washing with ether. This skin was aseptic, but it came from the groin and not from the scalp. Mr. Furnivall said that this mode of preparation caused great pain, and kept the patient awake all night. Nevertheless, there was no blistering or

eczema at the operation, which was one for the radical cure of hernia, and the wound healed by first intention under a single dressing.

In another case our failure to disinfect the skin seems to have been the direct cause of the suppuration of the wound. The patient was a delicate girl, who was prepared for the operation of radical cure of a congenital inguinal hernia. The skin was prepared by the carbolic acid method, and before the application of the glycerine of carbolic (1 in 40) was rinsed with 1 in 4,000 lotion of biniodide of mercury. The skin looked quite natural at the operation, but I grew from it a pure culture of *staphylococcus aureus*, as was proved by plate cultures.

The fifth day after the operation this patient's temperature rose, and she had slight pain in the wound; and when, at a later date, the dressing was removed, it was found to have suppurated. The pus contained *staphylococcus aureus* and a common green mould. This is the first time that I have grown *staphylococcus pyogenes aureus* from the skin, and it seems reasonable in this case to attribute the suppuration to it. Out of fifty-two operations for the radical cure of non-strangulated hernia, I have had five cases which had suppuration which led to the extrusion of the deep sutures, and three which had very slight superficial suppurations.

Evidently the solution of carbolic acid in water or in glycerine, whether used alone or supplemented with other chemicals, only gives aseptic results in less than half the cases. Of late I have been using biniodide of mercury for the cleansing and disinfection of sponges during operations. It is claimed for this drug that it is a powerful disinfectant, and it has the further advantage of not precipitating albumen. A mixture of blood and biniodide lotion remains quite translucent and clear. It was thought reasonable, therefore, to apply a solution of biniodide in glycerine to the skin in place of carbolic acid or sublimate. Therefore the skin of the groin of a boy who was about to be operated on for radical cure was washed with soft soap and water, scrubbed, rinsed with biniodide of mercury lotion (1 in 4,000), and covered with a dressing of carbolic gauze soaked in glycerine of biniodide (1 in 4,000). This skin was aseptic, and the wound healed by first intention under a single dressing. However, the experiment was performed under very advantageous circumstances, as the skin was white and clean, and obviously easy to disinfect.

A similar experiment, in which the biniodide glycerine was applied after the skin had been washed, scrubbed, treated with ether, and rinsed with carbolic lotion (1 in 20), resulted in the growth of *staphylococcus albus* from the piece dropped into broth. This patient was a young man upon whom I operated for the radical cure of both inguinal and femoral herniæ. Both wounds healed by first intention, and under a single dressing. Exactly the same method was used for the skin of the legs before an operation for the excision and ligature of varicose veins. This skin was somewhat blistered by preparation, and although the small wounds did well at first there was subsequently some slight suppuration.

Twenty-one experiments upon the disinfection of the skin have now been mentioned, and of these seven were successful. In six of these cases the wounds healed by first inten-

tion, and without the slightest pain or constitutional disturbance. There was very slight, delayed, secondary supuration in one—the resection of the knee—but this was probably due to a fault in the dressing, and led to no ill consequences. In the other fourteen cases the skin was septic; nine of these healed by first intention, and five supurated. In none of these was the suppuration severe or prolonged. The worst case was that in which the skin was infected with *staphylococcus aureus*.

Plate cultures of gelatine and agar agar were used to ascertain the kinds of bacteria grown from these bits of skin. *Staphylococcus aureus* was present once; *staphylococcus pyogenes* may have been present in some, but was not isolated; bacilli occurred twice. This is interesting because, although cocci are commonly met with in antiseptic wounds, bacilli are comparatively rare; indeed, in both of these cases they were mixed with micrococci. *Staphylococcus pyogenes albus* occurred seven times, *diplococcus epidermidis albus* thrice, *staphylococcus aureus* once, and the coccus with the cheesy odour twice; and once *albus* mixed with *citreus*. It is probable that several species are included under the term *staphylococcus pyogenes albus*, but I have included none but those which fulfilled the usual conditions, and which liquefied gelatine rapidly. I regret that experimental evidence has not been obtained as to the pathogenic properties of these bacteria. However, during the past year we have had such mortality amongst the animals that any attempts seemed sure to be fallacious.

II.—DISINFECTION OF THE HANDS.

A few experiments have been done to ascertain how far the skin of the hands can be disinfected. These have been conducted upon similar lines. After the cleansing and disinfecting, a bit of skin was removed with scissors and forceps, as in Reverdin's method of skin grafting, and dropped into broth. The mode of preparation was as follows: The nails were cut as close as possible and the hands thoroughly scrubbed with hot water and soap. The nail brush used for this purpose ought to have been sterilised by steaming for at least half an hour. This was seldom done, but soaking in carbolic lotion (1 in 20) for many hours was tried instead, but is probably quite ineffectual. Next the hands were rinsed with hot water and soaked in ordinary sublimate lotion (1 in 500) for a minute or a minute and a-half. This method gave aseptic results on two occasions. When a watery solution of biniodide of mercury (1 in 1,000) was used instead of sublimate the result was different and *staphylococcus pyogenes albus* grew in the broth. The nails were rather long when this test was applied to the skin, so a scrap was cut off and dropped into broth; cocci in twos and short chains were the result.

Of late a solution of sublimate in rectified spirit has been used for disinfecting the skin of the hands, and seems to promise the most reliable results. The nails have been removed as usual, the skin thoroughly scrubbed with soap and hot water and a nail brush, and the hands soaked for a minute in a 1 in 1,000 solution of sublimate in rectified spirit. In three experiments the skin was aseptic after this treatment.

and in one it grew staphylococcus albus. Twice the assistant left his nails long enough to supply a scrap to put into broth; once this grew a rather large lemon-yellow coccus, which grew on the surface and in the depths of gelatine, and slowly liquefied it, and once it grew an ordinary white mould. I am inclined to think that the spirit and sublimate method is the simplest and most reliable for the hands. Those who are interested will find various other methods in Sternberg's excellent *Manual of Bacteriology* (New York, 1892). The nails are clearly harder to disinfect than the skin. I do not believe it is possible to disinfect them except by cutting them as short as possible. In my previous report, an attempt at their disinfection was mentioned, which resulted in the subsequent growth of a streptococcus, probably streptococcus pyogenes.

Although these experiments upon the disinfection of the skin of the patient and upon the skin of the hands are few and incomplete, yet they seem to favour the assumption that glycerine or alcohol are better than water for the dilution of the chemicals. They also exemplify the extreme difficulty of the problem, and the rashness of those who talk about disinfection without having applied appropriate tests.

DISINFECTION OF TOWELS.

I have always felt distrustful of the towels which are now generally used to surround the field of operation. They are usually handed to the surgeon after having been dipped for a longer or shorter period in carbolic lotion. Nurses or sisters seldom use sublimate for this purpose, because it causes so much discoloration. Sixteen towels were examined in the usual way by cutting a scrap off and dropping it into broth. The results of attempts to disinfect with carbolic acid were as follows: Out of four which had been soaked for two hours in 1 in 20 carbolic lotion one was aseptic; the other three infected the broth with staphylococcus pyogenes albus, with cocci singly and in pairs and in strings of seven or less, and with a white mould.

Another towel, which had been kept in carbolic lotion 1 in 25 for twenty hours, grew a bacillus with a strong sebaceous odour, and it might be expected that towels would contain bacteria derived from the skin. A towel which had been kept in 1 in 20 carbolic lotion for twenty-four hours was aseptic. For reasons already given, mercurial preparations were seldom used for the disinfection of towels, but one which had been in 1 in 2,000 sublimate solution for some time contained bacillus subtilis, whilst another, which had been immersed for three hours in a solution of the same strength, was sterile. A towel which had been prepared by soaking for some hours in a weak solution of biniodide of mercury, 1 in 4,000, was also sterile. As it was clear that carbolic acid and other chemicals could not be relied upon to disinfect towels, we began to steam them for half an hour in an ordinary steam steriliser and in the operation theatre steam steriliser. The first attempt was a failure. Although the towel had been steamed for half an hour and soaked in 1 to 20 carbolic lotion for more than half an hour, it grew staphylococci, cocci in chains of six, and a spore-bearing bacillus, such as I have often seen in cultures in-

oculated with skin scrapings. I attributed this failure to the circumstance that the towel had been placed in the steriliser tightly folded up. In five other trials we had taken the precaution to open out the towels, and the result was aseptic in every instance. It seems as if this mode of preparation can be relied upon, the towel, of course, being soaked in an antiseptic after leaving the steriliser and whilst in use.

DISINFECTION OF SPONGES.

The sponges used at operations have been tested twelve times by thoroughly squeezing out as much lotion as possible, cutting a piece off and dropping it into broth. Obviously a certain amount of chemical must have been introduced each time into the broth, but the experiments mentioned at the beginning of this report show that it could have had no effect upon the ultimate result. The sponges were prepared and used as follows: The plan is most like that which Mr. Thornton³ recommends in his article upon ovariectomy. If new, the sponges were well shaken to get rid of all sand and left in a solution of hydrochloric acid (3j to Oj) for twenty-four hours, to remove the bits of coral and of shell. Next they are thoroughly washed and squeezed out in warm water, temperature 100° F., which has been boiled and left to cool in a covered vessel to ensure its sterility; from this they are transferred for half an hour to a warm solution of ordinary washing soda (3j to Oj water) for the removal of any fat or albumen. Sponges full of blood, fat, and albumen may require several repetitions of this part of the process. The soda solution is removed by again rinsing in warm sterilised water, temperature 100° F., and the sponges immersed in cold solution of sulphurous acid (1 in 5) for twelve hours for a final bleaching and sterilisation. During this stage a plate is placed over the sponges to sink them in the solution, otherwise they are apt to become discoloured. Lastly, they are squeezed as dry as possible, and placed in carbolic lotion (1 in 20) ready for the operation, at which they are handed to the surgeon or his assistant in a bowl of lotion. As carbolic acid evaporates, it is most important to have well-stoppered jars and to change the lotion not less than once a fortnight. The results of the twelve tests of this method showed that in every instance but one the sponges were aseptic. This does great credit to Nurse Duffus, who carried out the process. The failure occurred when she was away, and when an inexperienced nurse did the preparation. In this instance, the broth grew a micrococcus which had all the characters of *staphylococcus pyogenes albus*. Generally speaking, these experiments show that asepsis is with the greatest difficulty obtained with chemicals, but once obtained with either heat or chemicals, dilute solutions of chemicals suffice for its continuance.

³ Heath's *Dictionary of Practical Surgery*, vol. ii, p. 153.

